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Section 2 of 2

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APPENDIX B

ADDITIONAL TANK FARM INFRASTRUCTURE AND OPERATIONAL HISTORY INFORMATION

CONTENTS

FIGURES

TABLES

B.1.0 INTRODUCTION

This appendix includes additional figures and descriptions of C, A and AX tank farm infrastructure and operational history summaries. A brief description of unplanned releases that have occurred around the tank farms is also provided.

B.2.0 TANK FEATURES

WMA C encompasses the 241-C Tank Farm and is located in the east central portion of the 200 East Area. The 241-C Tank Farm contains twelve single-shell 100 series and four single-shell 200 series tanks constructed in 1943 and 1944. The 100 series tanks are 75 ft (22.9 m) in diameter, have a 15 ft (4.6 m) operating depth, and have an operating capacity of 530,000 gal (1,892,500 L) each. The 200 series tanks are 20 ft (6.1 m) in diameter with a 17 ft (5.2 m) operating depth and a capacity of 55,000 gal (208,000 L) each. Tank configuration and dimensions are shown in Figure B-1. The tanks sit below grade with at least 7 ft (2.1 m) of soil cover to provide shielding from radiation exposure to operating personnel. The inlet and outlet lines are located near the top of the liners (Figure B-2). The tanks in WMA C were removed from service between 1970 and 1980 (Hanlon 1999). The SSTs in the 241-C Tank Farm were used to store waste primarily from the bismuth phosphate, the PUREX, and the uranium extraction processes.

The SSTs were constructed in place with carbon steel (ASTM A283 Grade C) lining the bottom and sides of a reinforced concrete shell. The tanks have slightly concave bottoms and a curving intersection of the sides and bottom. This curvature decreased the buildup of stress in the bottom corners of the tanks, reducing corrosive effects and thus reducing the chance of developing a leak in the tank bottom.

The 241-A Tank Farm contains six 100 series single-shell tanks (SST) constructed from 1954 to 1955. The 241-AX Tank Farm contains four 100 series SSTs constructed from 1963 to 1964. These tanks have an operating capacity of 1 Mgal (3,785,400 L) each. Tank configuration and dimensions are shown in Figure B-3. The tanks are below grade with at least six feet of soil cover to provide radiation shielding to protect operating personnel. The inlet and overflow lines are located near the top of the liners. The 241-AX Tank Farm is the only one in the 200 East Area to have a system of underground leak detection pipes located horizontally under the tanks. Access to these laterals is through vertical 12 ft (3.7 m) diameter caissons sunk approximately 70 ft (21.3 m) below grade (Figure B-3).

The SSTs were constructed in place with carbon steel (American Society for Testing and Materials [ASTM] A283 Grade C in 241-A Tank Farm and ASTM A201 Grade C in 241-AX Tank Farm) lining the bottom and sides of a reinforced concrete shell. Although they are essentially the same as 241-A Tank Farm, the tanks in the 241-AX Tank Farm have a grid of drain slots beneath the steel liner bottom to collect potential tank leakage. Any leaked liquid is then diverted to a leak detection well. The grids also served as an escape route for free water released from concrete grout during initial heating of the tank.

The 241-A and 241-AX Tank Farms, along with 241-SX Tank Farm, contain the only tanks with a right angle intersection of the sides and the bottom. Most of the other SST tanks have a dished intersection between sides and bottom. The configuration of the side-bottom intersections and the method of welding combine to create inherent weaknesses at these locations when they are subjected to heat stresses. In at least one case (tank A-105), these weaknesses may have contributed to tank failure and leaks to the subsurface.

Figure B-1. Typical Configuration and Dimensions of Single-Shell Tanks in C WMA (Modified from Hanlon 1999).

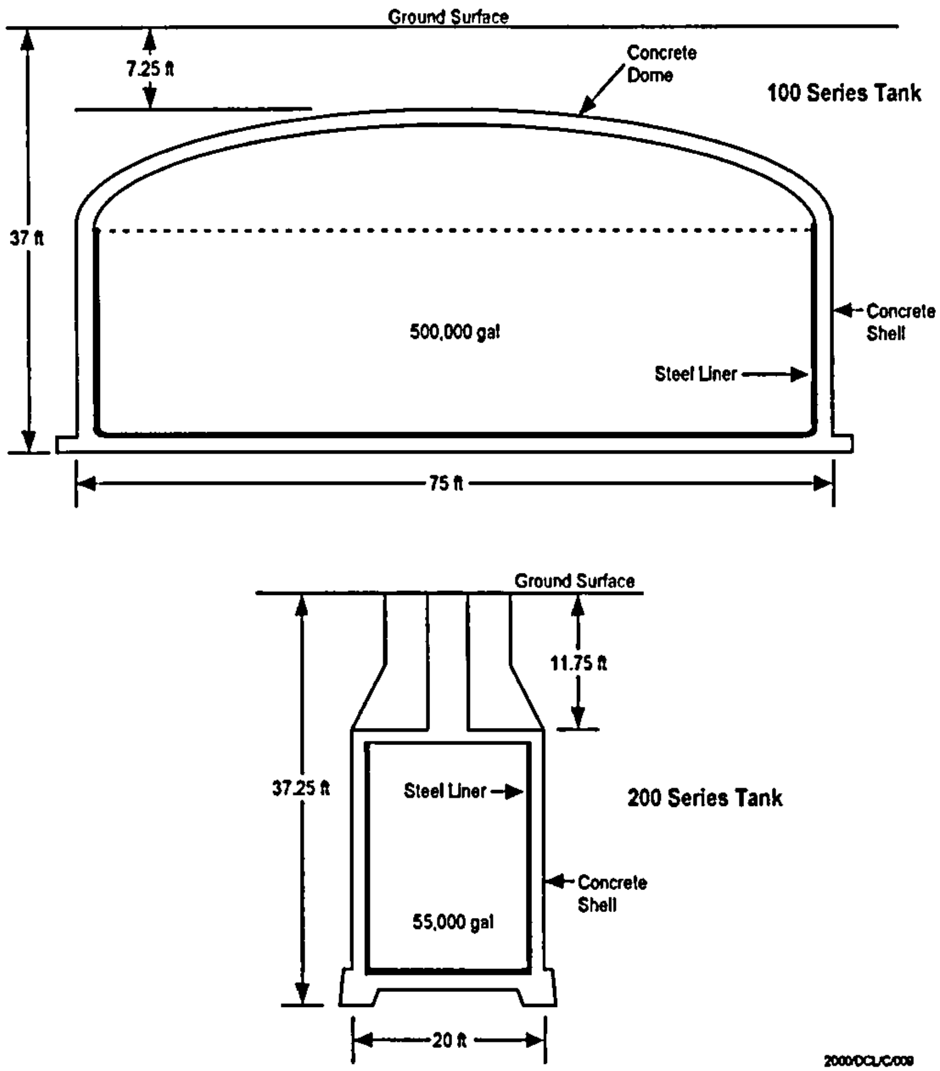


Figure B-2. Typical Single-Shell Tank Instrumentation Configuration at C WMA (from DOE 1993).

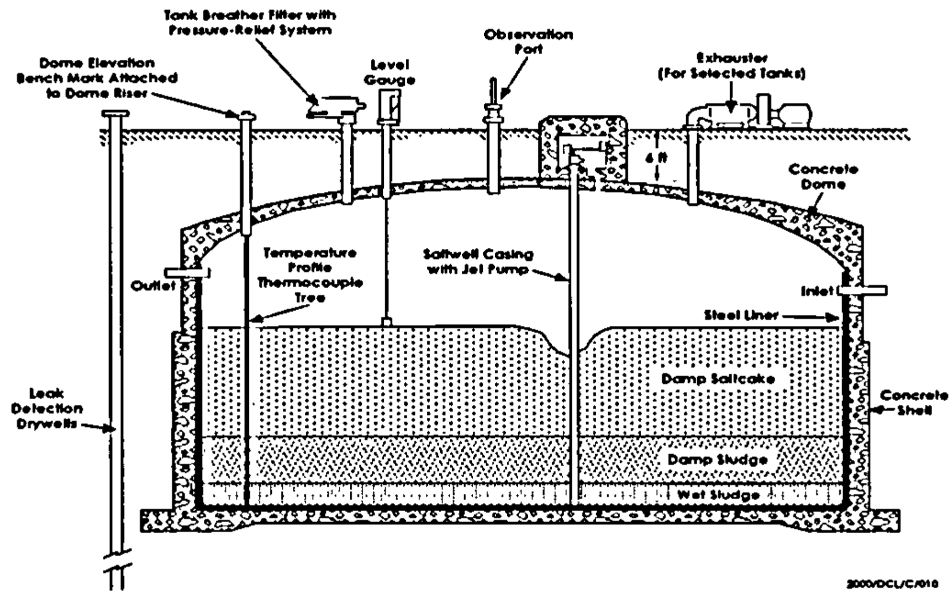
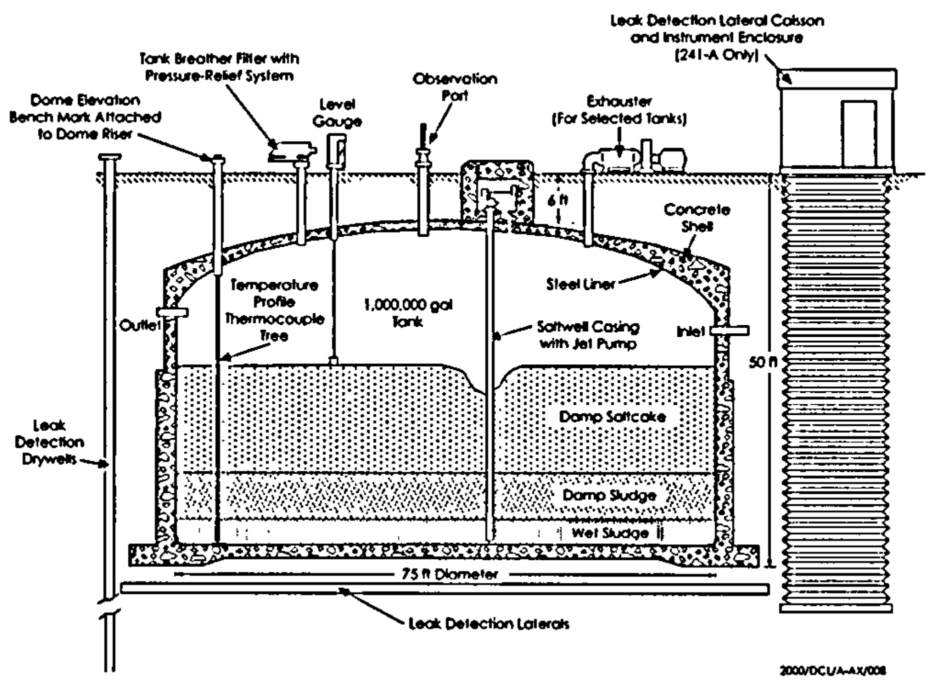


Figure B-3. Schematic Showing the Construction of a Typical Single-Shell Tank at A-AX WMA with a 1 Mgal Capacity (after DOE/RL 1996).

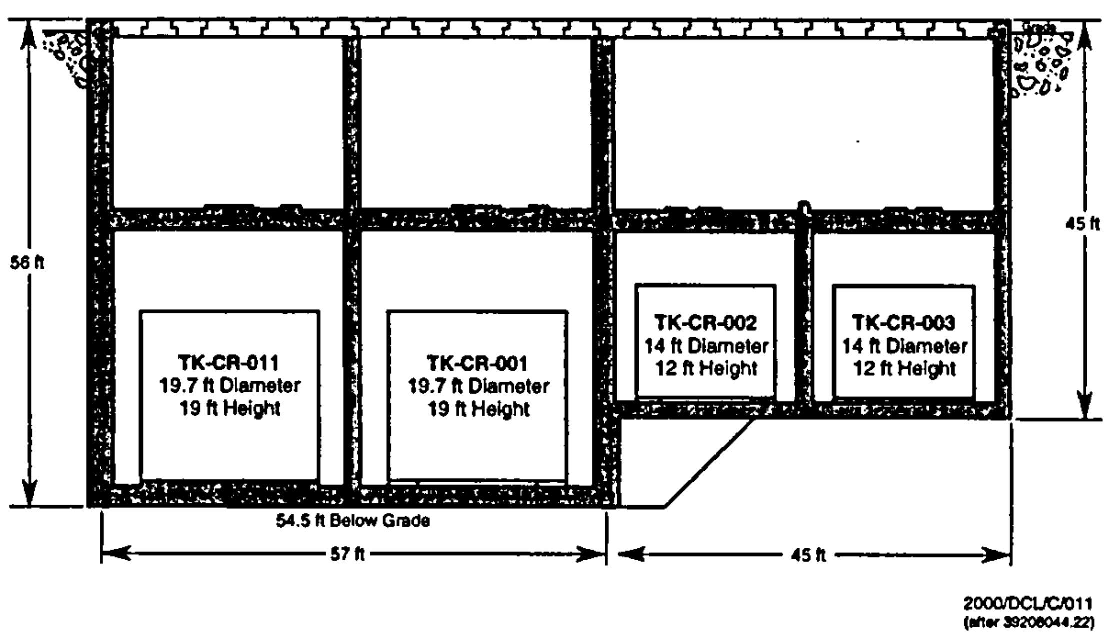


B.3.0 OTHER STRUCTURES

WMA C includes the 244-CR vault and eight diversion boxes. The 244-CR vault is located in the 241-C Tank Farm, south of the tanks. The vault is a two level, multi-cell, reinforced concrete structure constructed below grade (DOE 1993). The 244-CR vault (Figure B-4) contains four permitted underground tanks along with overhead piping and equipment. Two tanks (244-CR-001 and 244-CR-011) have diameters of 19.7 ft (6 m), are 19 ft (6 m) tall, and have a capacity of 45,000 gal (170,343 L) each. The other two tanks (244-CR-002 and 244-CR-003) are 14 ft (4 m) in diameter, 12 ft (3.7 m) tall, and have capacities of 14,700 gal (55,494 L) each. This vault was constructed in 1946 and ceased operating in 1988. It was used to transfer waste solutions from processing and decontamination operations (DOE 1993). Only tanks 244-CR-003 and 244-CR-011 are listed in DOE/RL-88-21, *Dangerous Waste Permit Application; Single-Shell Tank System,* as part of the WMA.

A similar structure, the 244-AR Vault (Figure B-5) is located next to the A tank farm and contains four permitted underground tanks along with overhead crane operations equipment. Constructed in 1976, the four underground units are stainless steel waste storage tanks. Also included are high-pressure pumps used to transfer water or tank supernate through specially designed nozzles to tanks being sluiced.

Figure B-4. Schematic of the 244-CR Vault in WMA C (from DOE/RL 1996).



Non-boiling liquid waste from the operations building was sent to the tank farms via underground lines and diversion boxes. Leaks occurred in the diversion boxes or into the surrounding line encasement drain and were collected by catch tanks. The leaked liquids were then pumped to the large SSTs. These transfer lines and diversion boxes are listed as part of the WMA in the Part A permit (DOE/RL-88-21). The catch tanks, however, are not listed as being part of the managed Resource Conservation and Recovery Act (RCRA) WMA.

In addition to the tanks and vaults seven inactive diversion boxes were constructed at A-AX WMA and eight at C WMA that are designated as waste piles along with the transfer pipes to the DST systems and associated equipment (DOE/RL-88-21) (Figure B-6). All diversion boxes used within the farms are inactive and presently isolated or covered from the weather. As used here, "isolated" means exterior water intrusion has been restricted. The diversion boxes are included in the RCRA permit application because they were an integral part of the waste transfer system. The boxes are important in the plan because some were the sites of contaminant releases to the subsurface. It is estimated that each box contains 50 lbs (23 kgm) of lead, and they are listed as waste piles (Hanlon 1999).

Figure B-5. Schematic of the 244-AR Vault, Which Consists of Four Smaller Tanks with Dimensions and Storage Capacities as Shown.

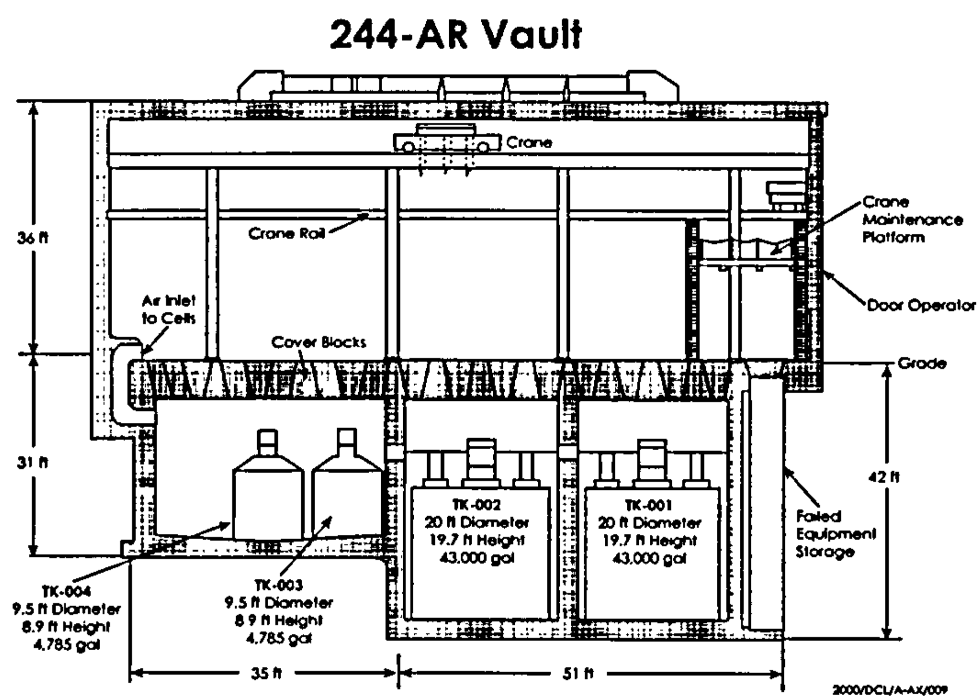
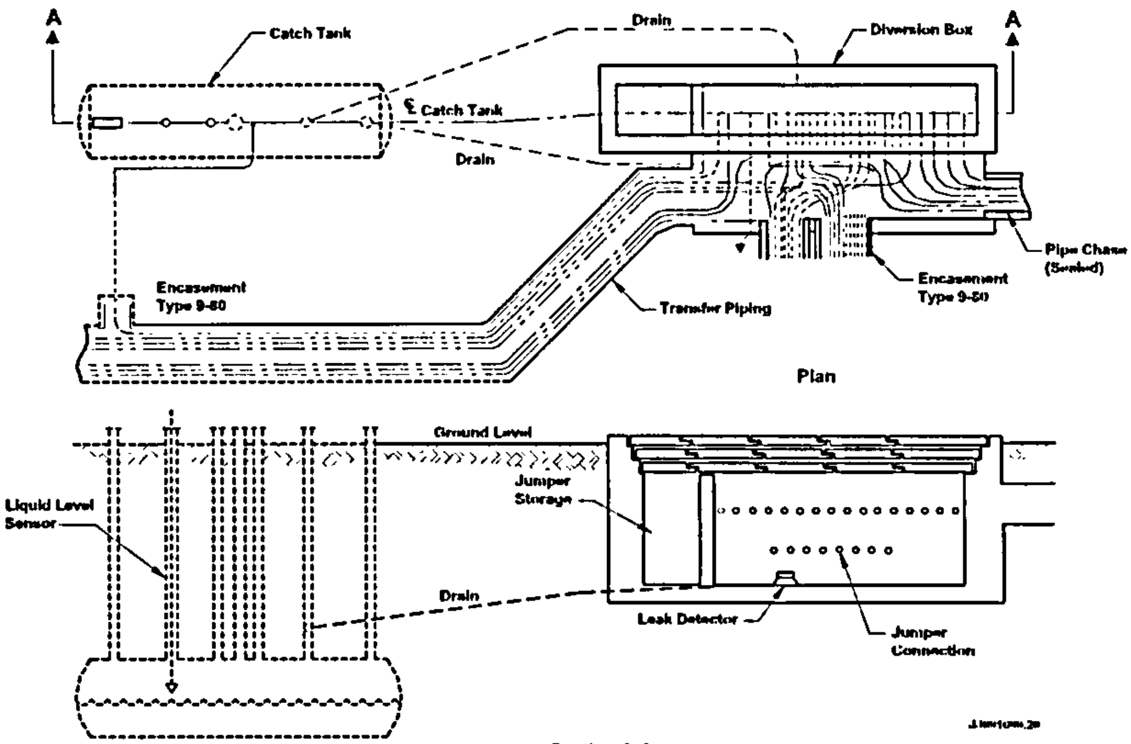


Figure B-6. Schematic of a Typical Diversion Box Transfer System.



B.4.0 SUMMARY TABLES OF OPERATIONAL HISTORY

Documented information on the operational history of the SSTs, the waste transfer vault, and the diversion boxes that are part of the C WMA is provided in three tables. Table B-1 lists the tank, vault and diversion box numbers, year of construction, year removed from service, and operating capacity or function. Tanks from which leaks that are officially considered as confirmed or assumed are listed in Table B-2 along with the estimated volume of leaked waste and the date that the tank was interim stabilized. Interim stabilized means that the tank now contains less than 50,000 gal (189,250 L) of drainable interstitial liquid and less than 5,000 gal (18,925 L) supernatant liquid (Hanlon 1999). Note that in the review of tank leaks in Chapter 3 of this document, the conclusions concerning tank status and leak volume estimates are not in agreement with Table B-2. None of the tanks listed appear to have leaked although infrastructure parts around some of the individual tanks (e.g., transfer lines) do seem to have leaked. Also, tank C-105, which does not appear in Table B-2, is proposed in this document to have leaked.

Table B-3 provides the current inventory and status of the SSTs in the C WMA. Most of the pumpable liquid has been removed and transferred to DSTs as part of the interim stabilization project. Interim stabilized means that the tank now contains less than 50,000 gal (189,250 L) of drainable interstitial liquid and less than 5,000 gal (18,925 L) of supernatant liquid. However, two tanks (241-C-103 and 241-C-106) are not yet interim stabilized, although tank 241-C-106 has been sluiced. As used in Table B-3, intrusion prevention (IP) is the administrative designation for the completion of the physical activities required to minimize the addition of liquids into an inactive storage tank. Electrical and other instrumentation devices are not disconnected during intrusion prevention. Partially interim isolation (PI) is the administrative designation for the completion of physical activities required for interim isolation except for isolation of risers and piping required for jet pumping or other stabilization methods (Hanlon 1999).

Pertinent information on the A-AX tanks, waste transfer vault, and the diversion boxes is provided in three tables. Table B-4 lists the tanks, vault, and diversion box numbers, year of construction, year removed from service, and operating capacity. The date a tank was declared a leaker, the volume of leaked waste and associated curies is provided in Table B-5. Table B-6 provides the current inventory and status of the 100 series tanks in A-AX WMA. Data on tank integrity, the total waste in the tank, total pump able liquid remaining in the tanks, total liquid pumped out of the tank during interim stabilization and the sludge/salt cake volumes for each tank are included in this table (Hanlon 1999). Note that in the review of tank leaks in Chapter 3 of this document, the conclusions concerning tank status are not in agreement with Table B-5. In Chapter 3, it was concluded that only tank A-105 itself leak. Some transfer line leaks around other tanks are likely.

Table B-1. Operating Period and Capacities for WMA C Facilities[a].

Facility	Constructed	Removed From Service	Operating Capacity (gal)
Single-Shell Tanks			
241-C-101	1943 - 1944	1970	530,000
241-C-102	1943 - 1944	1976	530,000
241-C-103	1943 - 1944	1979	530,000
241-C-104	1943 - 1944	1980	530,000
241-C-105	1943 - 1944	1979	530,000
241-C-106	1943 - 1944	1979	530,000
241-C-107	1943 - 1944	1978	530,000
241-C-108	1943 - 1944	1976	530,000
241-C-109	1943 - 1944	1976	530,000
241-C-110	1943 - 1944	1976	530,000
241-C-111	1943 - 1944	1978	530,000
241-C-112	1943 - 1944	1976	530,000
241-C-201	1943 - 1944	1977	55,000
241-C-202	1943 - 1944	1977	55,000
241-C-203	1943 - 1944	1977	55,000
241-C-204	1943 - 1944	1977	55,000
Diversion Boxes			Function
241-C-151	1946	1985	Interconnected 241-C-152, -153, and CR-151 diversion boxes
241-C-152	1946	1985	Interconnected 241-B-154 and -153 and 241-C Tank Farm, associated with the 241-C-301 Catch Tank
241-C-153	1946	1985	Interconnected 241-C-151 and -152 diversion boxes
241-C-154	1965	1985	Interconnected B-Plant to Hot Semi-Works locations. Box located at Hot Semi-Works
241-C-252	1946	1985	Interconnected 241-C-151 diversion box and 241-C Tank Farm
241-CR-151	1952	1985	Interconnected 241-C-151 and 241-C Tank Farms
241-CR-152	1946	1985	Interconnected 241-C-151 diversion box and 241-C Tank Farm
241-CR-153	1946	1985	Interconnected 241-CR-152 diversion box and 241-C Tank Farm
244-CR-Vault			
244-CR-011	1946	1988	Transfer of waste solutions from processes and decontamination operations.
244-CR-003	1946	1988	

[a] Data on SSTs is from Caggiano and Goodwin (1991) and Hanlon (1999). Data on diversion boxes and the 244-CR vault is from DOE (1993a) except for 241-C-154, which is from DOE (1993b).

Table B-2. Tank Leak Volume Estimates (from Hanlon 2000).

Tank Number	Date Declared Confirmed or Assumed Leaker	Volume Leaked (gal)	Interim Stabilized Date	Leak Estimate Updated
241-C-101	1980	20,000	11/83	1986
241-C-110	1984	2,000	5/95	1989
241-C-111	1968	5,500	03/84	1989
241-C-201	1988	550	03/82	1987
241-C-202	1988	450	08/81	1987
241-C-203	1984	400	03/82	1986
241-C-204	1988	350	09/82	1987

Table B-3. Inventory and Status by Tank (from Hanlon 2000).

Tank	Tank Integrity	Stabilization/ Isolation Status[a]	Total Waste (gal x 1000)	Total Pumped (gal x 1000)	Drainable Liquid Remaining (gal x 1000)	Pumpable Liquid Remaining (gal x 1000)	Sludge (gal x 1000)	Salt Cake (gal x 1000)
241-C-101	Assumed leaker	IS/IP	88	0.0	4	0	88	0
241-C-102	Sound	IS/IP	316	46.7	62	55	316	0
241-C-103	Sound	/PI	198	0.0	83	83	119	0
241-C-104	Sound	IS/IP	295	0.0	34	30	295	0
241-C-105	Sound	IS/PI	134	0.0	12	8	132	0
241-C-106	Sound	/PI	74	0.0	68	62	6	0
241-C-107	Sound	IS/IP	257	40.8	30	25	257	0
241-C-108	Sound	IS/IP	66	0.0	4	0	66	0
241-C-109	Sound	IS/IP	66	0.0	6	4	62	0
241-C-110	Assumed leaker	IS/IP	178	15.5	38	30	177	0
241-C-111	Assumed leaker	IS/IP	57	0.0	4	0	57	0
241-C-112	Sound	IS/IP	104	0.0	6	1	104	0
241-C-201	Assumed leaker	IS/IP	2	0.0	0	0	2	0
241-C-202	Assumed leaker	IS/IP	1	0.0	0	0	1	0
241-C-203	Assumed leaker	IS/IP	5	0.0	0	0	5	0
241-C-204	Assumed leaker	IS/IP	3	0.0	0	0	3	0

[a] IP = Intrusion Prevention; IS = Interim stabilized or isolated; and PI = Partially interim isolation.

Table B-4. Summary Data for Facilities Comprising WMA A-AX.

Tank Number	Year of Construction	Year Removed from Service	Operating Capacity (gal)
241-A-101	1954-1955	1980	1,000,000
241-A-102	1954-1955	1980	1,000,000
241-A-103	1954-1955	1980	1,000,000
241-A-104	1954-1955	1975	1,000,000
241-A-105	1954-1955	1963	1,000,000
241-A-106	1954-1955	1980	1,000,000
241-AX-101	1963-1964	1980	1,000,000
241-AX-102	1963-1964	1980	1,000,000
241-AX-103	1963-1964	1980	1,000,000
241-AX-104	1963-1964	1978	1,000,000
Diversion Box	**Year of Construction**	**Year Removed from Service[a]**	**Operating Capacity (lbs)**
241-A-152	1955	1985	NA
241-A-153	1966	1985 (?)	NA
241-AX-151	1963	1985	NA
241-AX-152	1962	NA	NA
241-AX-155	1983	1985 (?)	NA
241-AY-151	1975	1985 (?)	NA
241-AY-152	1970	1985 (?)	NA
Tank Number	**Year of Construction**	**Year Removed from Service**	**Operating Capacity (gal)**
244-AR-001	1976	NA	43,000
244-AR-002	1976	NA	43,000
244-AR-003	1976	NA	4,785
244-AR-004	1976	NA	4,785

NA = Not applicable.

[a] Isolation date.

Table B-5. Tank Leak Volume Estimates (After Hanlon 1999).

Tank Number	Date Declared Confirmed or Assumed Leaker	Volume Leaked (gal)	Associated Kilocuries ^{137}Cs	Interim Stabilized Date	Leak Estimate Updated
241-A-103	1987	5,500		06/88	1987
241-A-104	1975	500 to 2,500	0.8 to 1.8	09/78	1983
241-A-105	1963	10,000 to 277,000	85 to 760	07/79	1991
241-AX-102	1988	3,000		09/88	1989
241-AX-104	1977	8,000		08/81	1989

Table B-6. Inventory and Status by Tank (After Hanlon 1999).

Tank	Tank Integrity	Stabilization/ Isolation Status	Total Waste (Kgal)	Total Pumped (Kgal)	Drainable Liquid Remain (Kgal)	Pumpable Liquid Remain (Kgal)	Sludge (Kgal)	Salt Cake (Kgal)
A-101	Sound	PI	953	0.0	721	697	3	442
A-102	Sound	IS/PI	41	39.5	6	0	15	22
A-103	Assumed leaker	IS/IP	371	111.0	20	0	366	0
A-104	Assumed leaker	IS/IP	28	0.0	0	0	28	0
A-105	Assumed leaker	IS/IP	19	0.0	4	0	19	0
A-106	Sound	IS/IP	126	0.0	7	0	126	0
AX-101	Sound	PI	748	0.0	558	534	3	359
AX-102	Assumed leaker	IS/IP	39	13.0	17	3	7	28
AX-103	Sound	IS/IP	112	0.0	36	3	2	110
AX-104	Assumed leaker	IS/IP	7	0.0	0	0	7	0

IP = Intrusion prevention.

IS = Interim stabilized or isolated.

PI = Partially interim.

B.5.0 UNPLANNED RELEASES

In addition to leaks historically attributed to tanks, a total of seventeen unplanned releases have been reported in and around the tank farms (12 in C farm, 3 in A farm and 3 in AX tank farm). The following brief descriptions of these events is provided:

- Unplanned release UPR-200-E-16 is a surface spill that resulted from a leak in an over ground transfer pipeline between tanks 241-C-105 and 241-C-108. The surface spill associated with this release is located approximately 60 ft (18 m) northeast of tank 241-C-105 and occurred in 1959. The spilled liquid was classified as coating waste from the PUREX process.
- Unplanned release UPR-200-E-18 was moisture dripping from a vent pipe bonnet at the 241-A-08 valve pit near 241-A-271 building that contaminated the ground in 1959. Volume estimates and remediation efforts are not described.
- Unplanned release UPR-200-E-27 is located just east of the 244-CR vault and extends easterly beyond the tank farm fence line. DOE (1993) indicates the surface contamination was deposited in 1960, but does not specify the source or potential sources of the contamination.
- Unplanned release UPR-200-E-42 was surface contamination that resulted from inadvertent pressurization in the 244-AR vault in 1972. The area around diversion box 241-AX-151.
- Unplanned release UPR-200-E-48 occurred at the tank A-106 pump pit in 1974 and was confined to a small area within the pump pit (DOE-GJO 1999). Beta-gamma readings of 1,000 to 2,000 counts per minute were detected. The contaminated materials were removed immediately.
- Unplanned release UPR-200-E-68 was wind-borne surface contamination spread from the 241-C-151 diversion box. The release occurred in 1985 and was subsequently decontaminated or covered with clean sediment.
- Unplanned release UPR-200-E-72 is located south of the 241-C Tank Farm and occurred in 1985. The source of the contamination was buried contaminated waste. The waste posed little release potential because the contamination was fixed in place. The source of contamination was stabilized and the area posted as a radiologically controlled area. The volume of the contamination was not specified.
- Unplanned release UPR-200-E-81 is located near the 241-CR-151 diversion box and the 244-CR vault. It occurred as a result of a leak in an underground transfer pipeline in October 1969. The waste leaked from the pipeline consisted of PUREX coating waste. The site was covered with gravel.
- Unplanned release UPR-200-E-82 is located near the 241-C-152 diversion box and was the result of a leak from an underground pipeline from the 202-A building to the 241-C-102 tank by way of the 241-CR-151 diversion box. The release occurred in December 1969. The leak spilled an estimated 10,000 L of waste. The contaminated site was covered with clean gravel.

- Unplanned release UPR-200-E-86 was a spill that resulted from a leak in a pipeline used to transfer waste from the 244-AR vault to the 241-C Tank Farm. The release was approximately 8 ft (2.4 m) below the ground surface. It occurred in March 1971 and is located just outside the west corner of the tank farm. The spill was estimated to include 25,000 Ci of ^{137}Cs. The sediments surrounding the pipeline were sampled and it was determined the contamination had not penetrated below 20 ft. The contamination plume volume was estimated at 1,300 cubic feet.
- Unplanned release UPR-200-E-91 is located approximately 100 ft from the northeast side of C tank farm. It resulted from surface contamination that migrated from the 241-C Tank Farm. The date of the occurrence, its areal extent, and the nature of the contamination are not specified. DOE (1993) states that the contaminated sediment was removed and the area was released from radiological controls.
- Unplanned release UPR-200-E-99 was surface contamination that resulted from numerous piping changes associated with the 244-CR vault. It is located west of the 244-CR vault and was established as a release site in 1980 although the actual occurrence date is unknown. The site was decontaminated in 1981.
- Unplanned release UPR-200-E-100 was a surface spill of unknown proportions and constituents that occurred in 1986. It is located about 200 ft (60 m) south and east of the 241-C Tank Farm and surrounds the 244-A lift station.
- Unplanned release UPR-200-E-107 was a surface spill located north of the 244-CR vault, inside the 241-C Tank Farm. DOE (1993) states that a spill occurred on November 26, 1952 when a pump discharged liquid to the ground surface during a pump installation. The spilled waste was tributyl phosphate waste from 221-U building. The proportions of the spill and any cleanup actions were not documented.
- Unplanned release UPR-200-E-115 was a pipeline bleed from the tank AX-103 pump pit that occurred in 1974. The contaminated soil was removed and disposed.
- Unplanned release UPR-200-E-119 was moisture transferred from a contaminated electrode cable to soil when the cable that was briefly set on the ground. The cable had been retrieved from tank AX-104.
- Unplanned release UPR-200-E-118 was located in the northeast portion of C tank farm and extends north up to about 300 m beyond the fence line. It was the result of an airborne release from tank 241-C-107 that occurred in April 1957. The highest exposure rate was estimated at 50 mrem/hour at the ground surface (DOE 1993).
- Unplanned release UPR-200-E-145 was the discovery of contaminated soil around a shallow pipe running between valve pit 241-A-08 and crib 216-A-34 in 1993. The actual data of leakage and volume leaked is unknown.

B.6.0 REFERENCES

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APPENDIX C

SUPPORTING STRATIGRAPHIC INFORMATION

CONTENTS

FIGURES

C.1.0 INTRODUCTION

Appendix C provides the detailed stratigraphic cross sections used to construct the subsurface physical model of the C and A-AX Waste Management Areas. Figures C-1 through C-.5 show 5 cross sections of the C and A-AX WMAs. Figures C-6 through C-15 show thickness isopachs and elevations of stratigraphic units in the vadose zone.

Figure C-1. Cross Section A-A--Northwest to Southeast Section of Vadose Zone Underlying C and A Tank Farms.

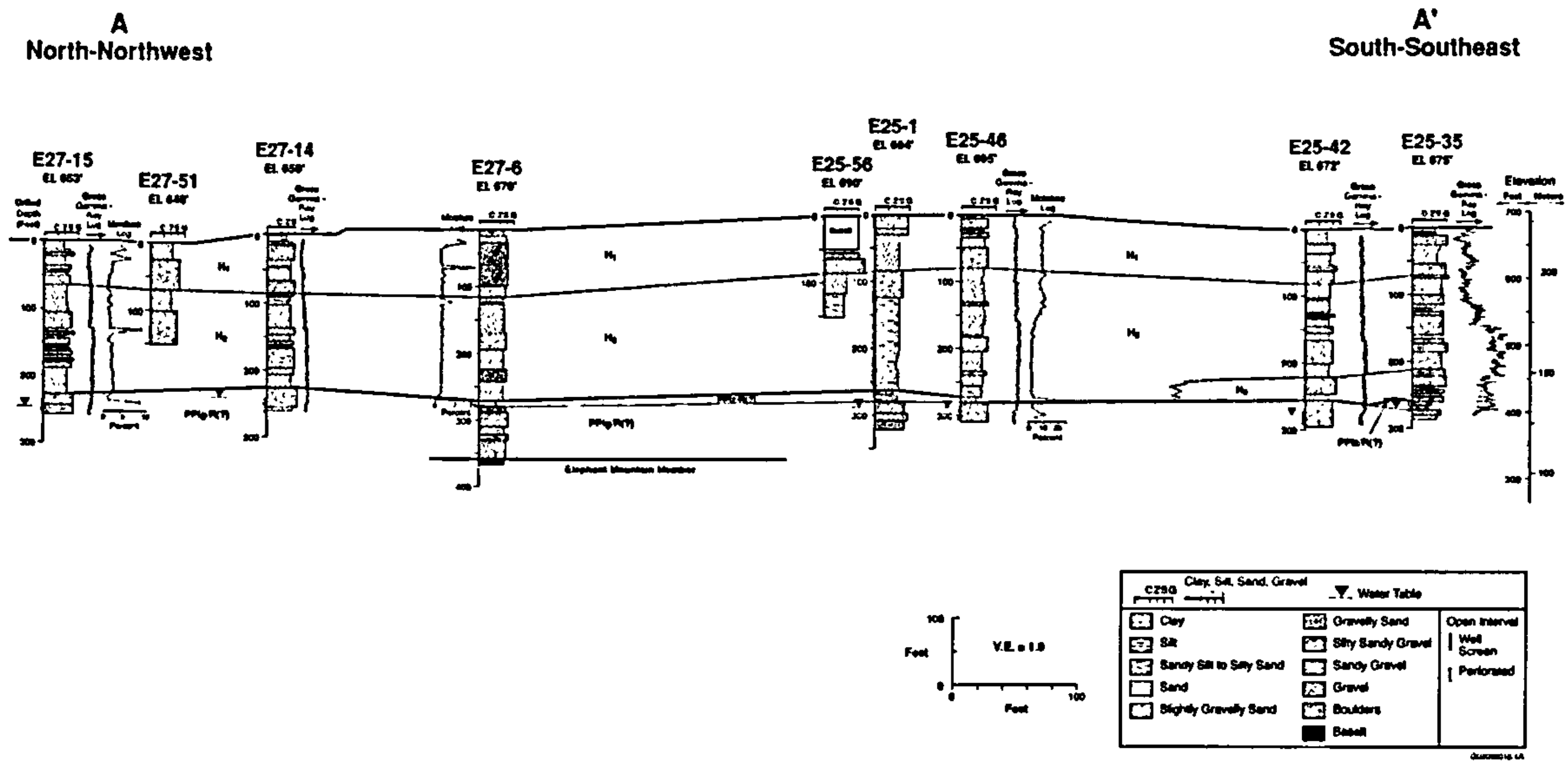

Figure C–2. Cross Section B-B--West to East Section of Vadose Zone Underlying A Tank Farm.

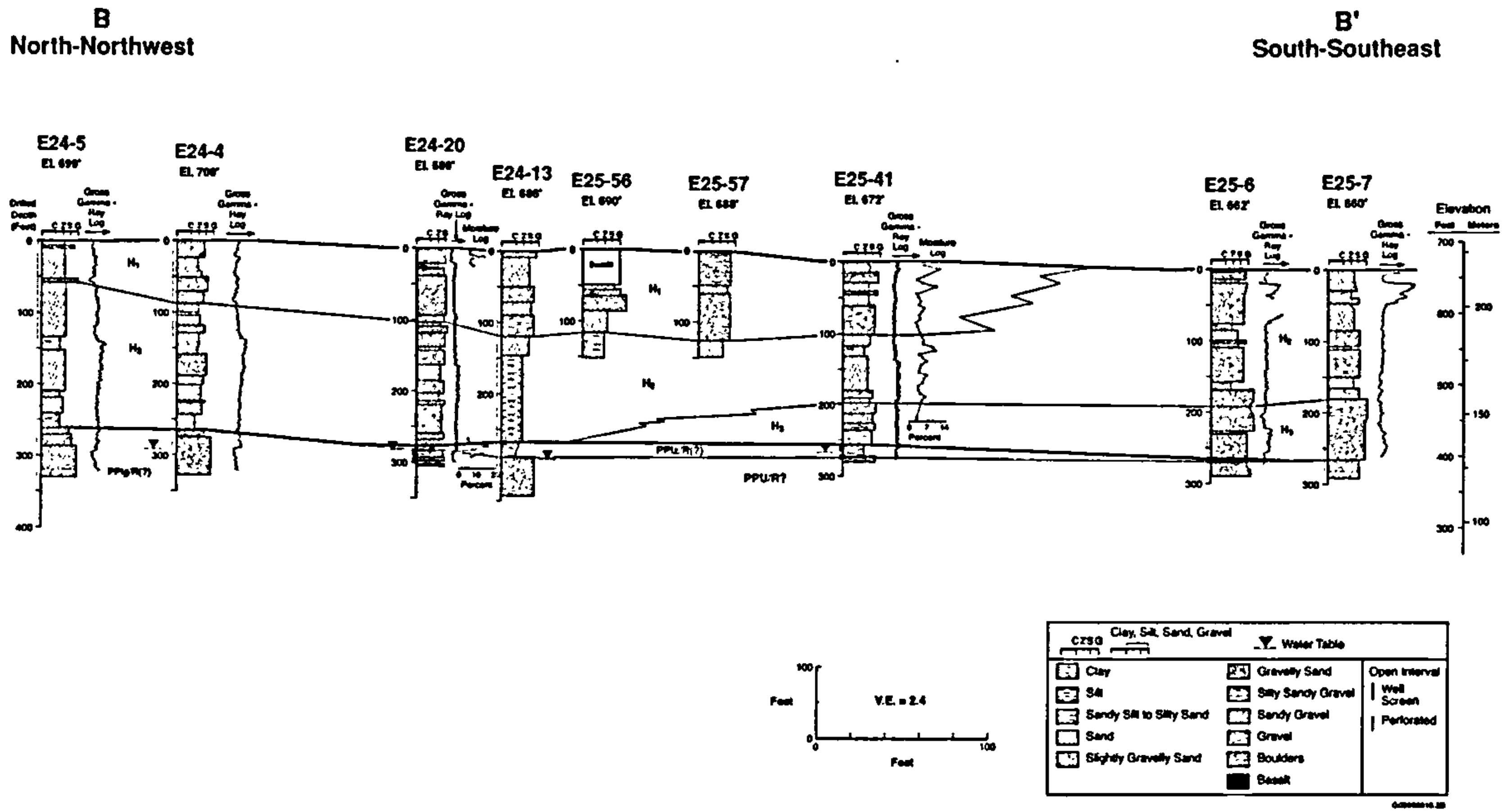

Figure C–3. Cross Section C-C--West to East Section of Vadose Zone Between C and A-AX Tank Farms.

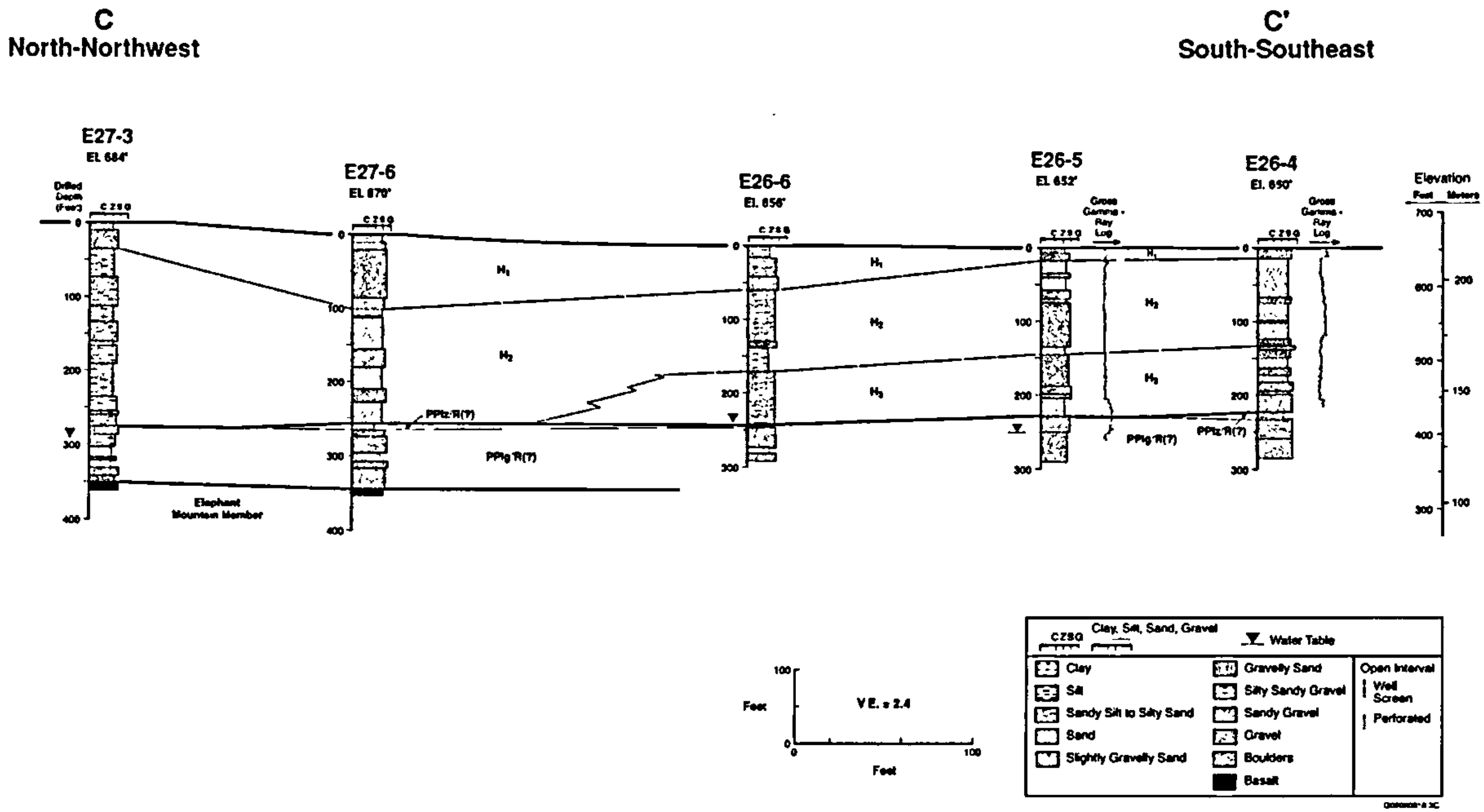

Figure C-4. Cross Section D-D--Southwest to Northeast Section of Vadose Zone Just South of C Tank Farm.

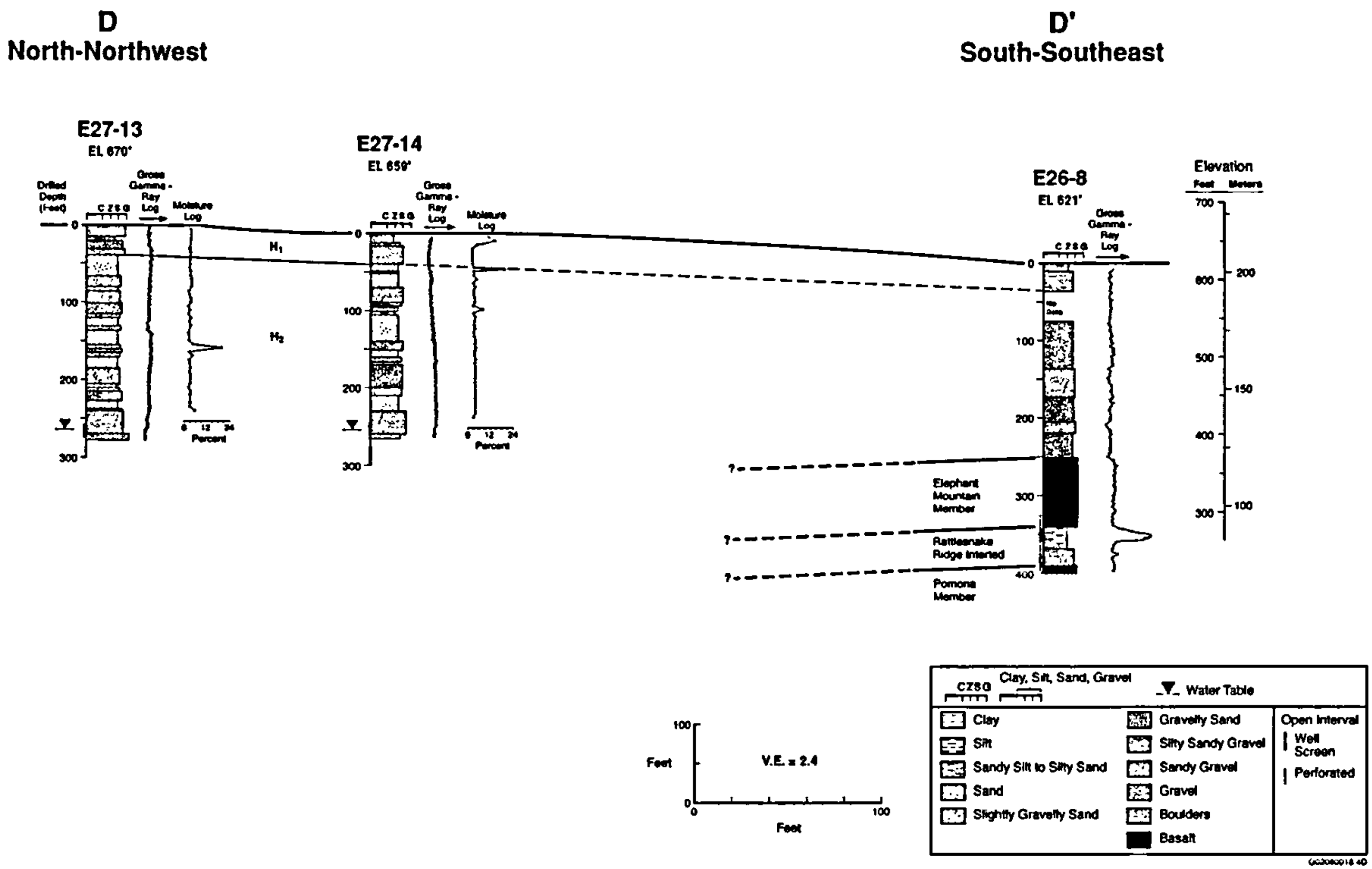

Figure C–5. Cross Section E-E--Northwest to Southeast Section of Vadose Zone Underlying AX Tank Farm

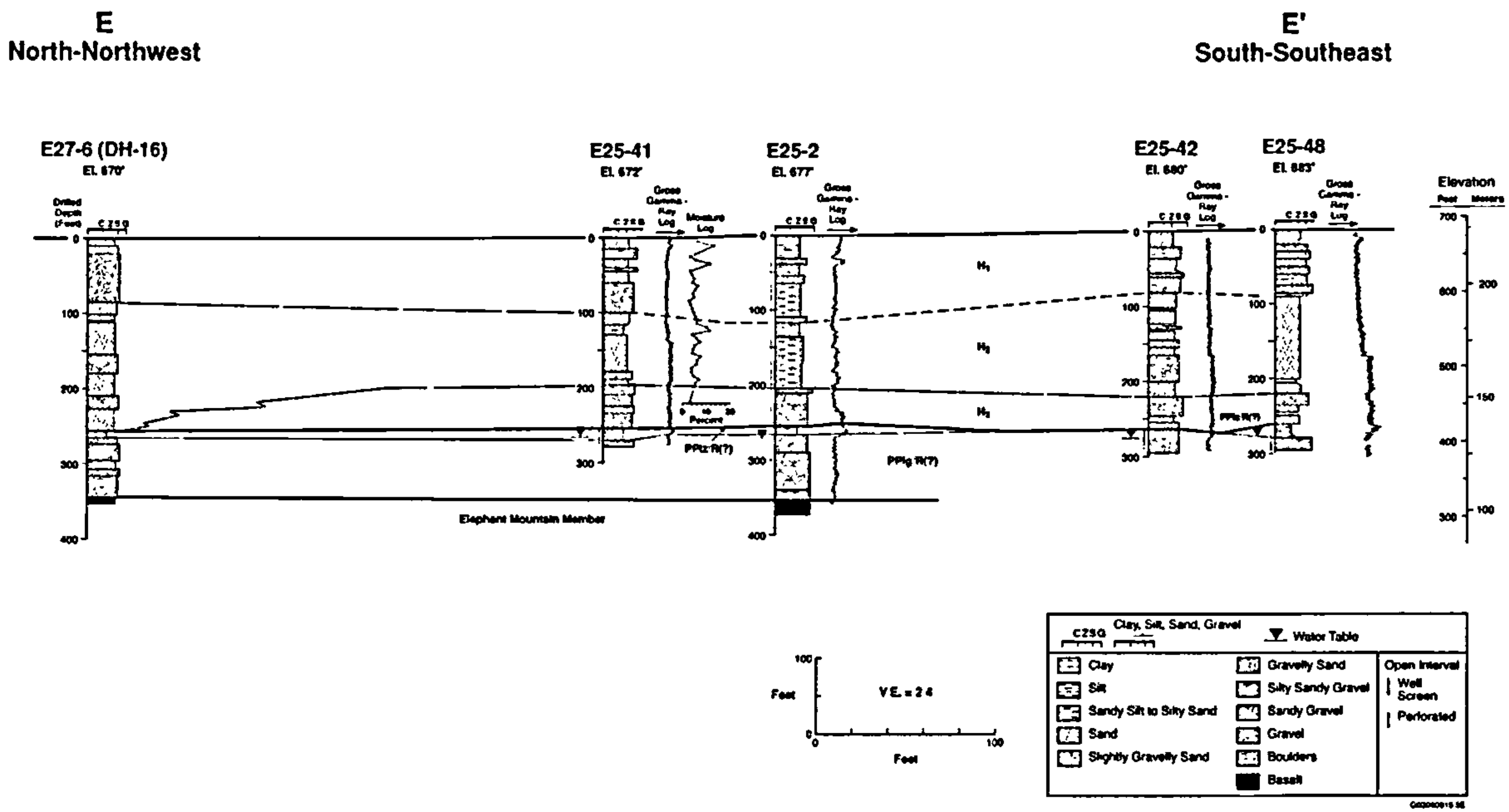

Figure C–6. Structure Contour Map of the Top of Basalt.

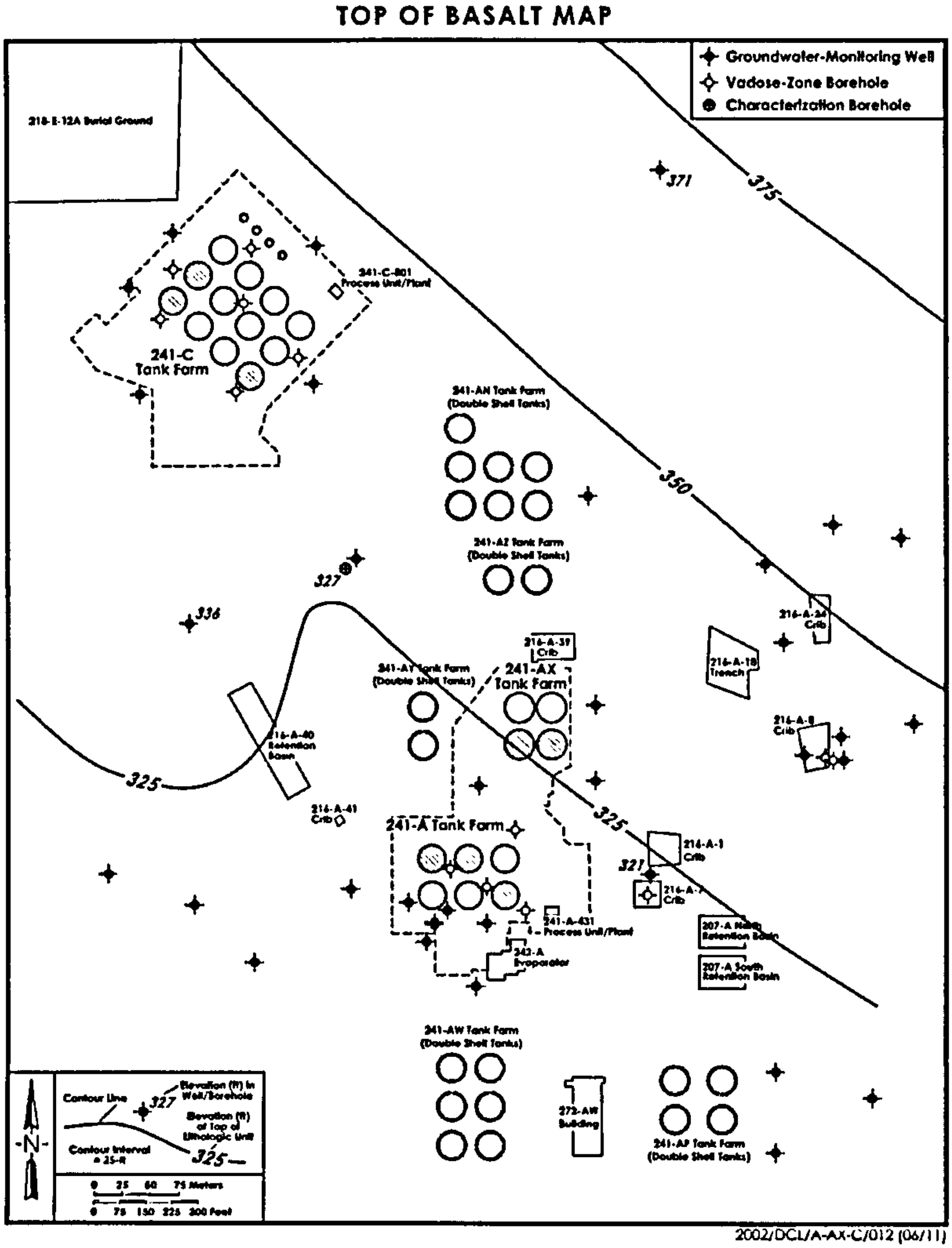

Figure C–7. Structure Contour Map of the Top of the Undifferentiated Plio-Pleistocene Gravels/Ringold Formation Unit A [Pplg/R(?)] Unit.

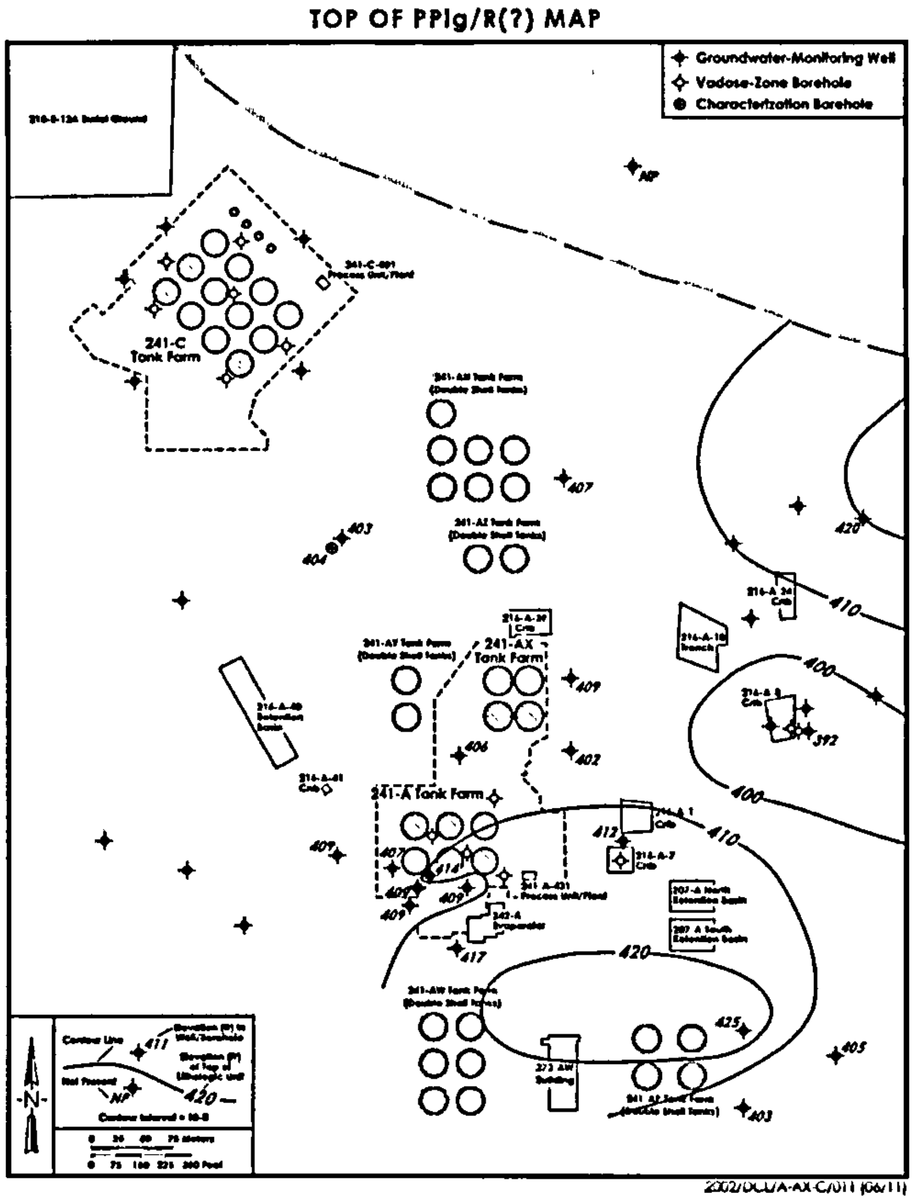

Figure C–8. Isopach Map of the Undifferentiated Plio-Pleistocene Silt/Ringold Formation Mud? [Pplz/R(?)] Unit.

PPlz/R(?) ISOPACH MAP

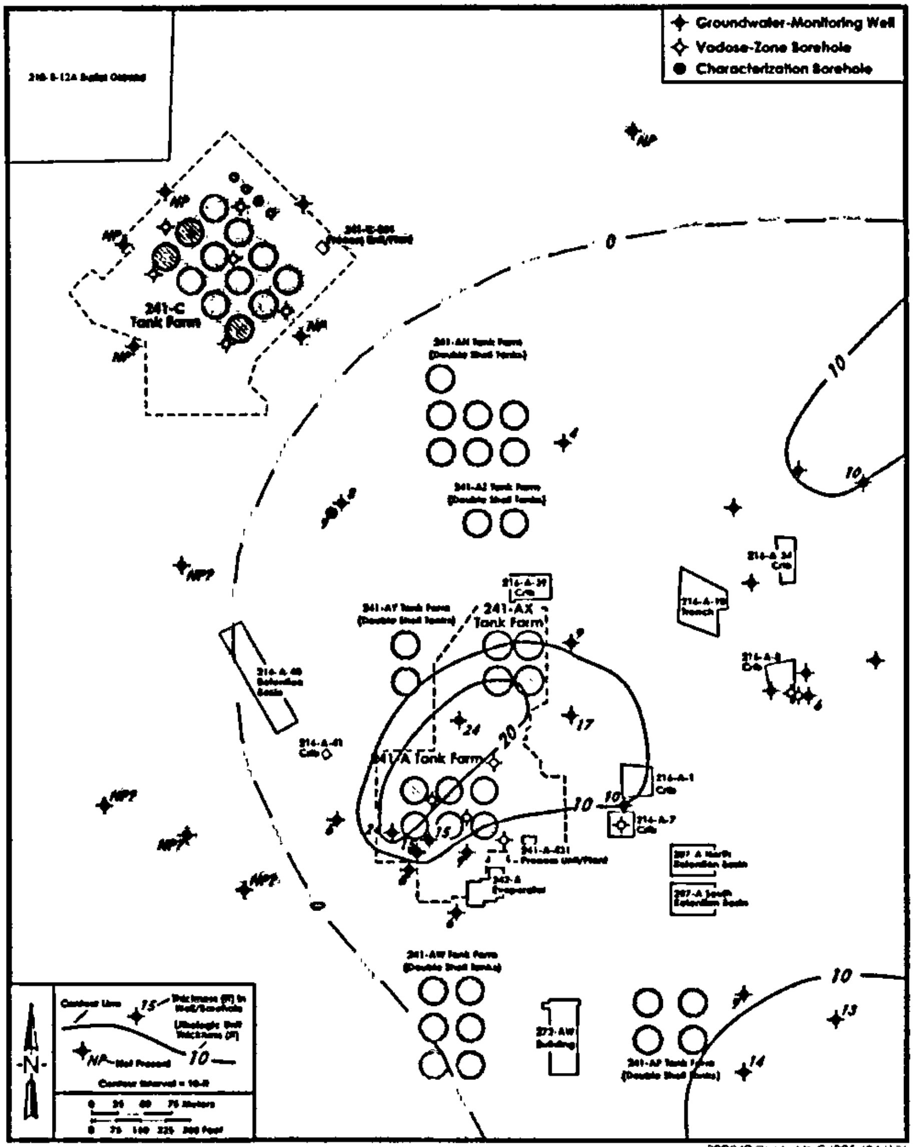

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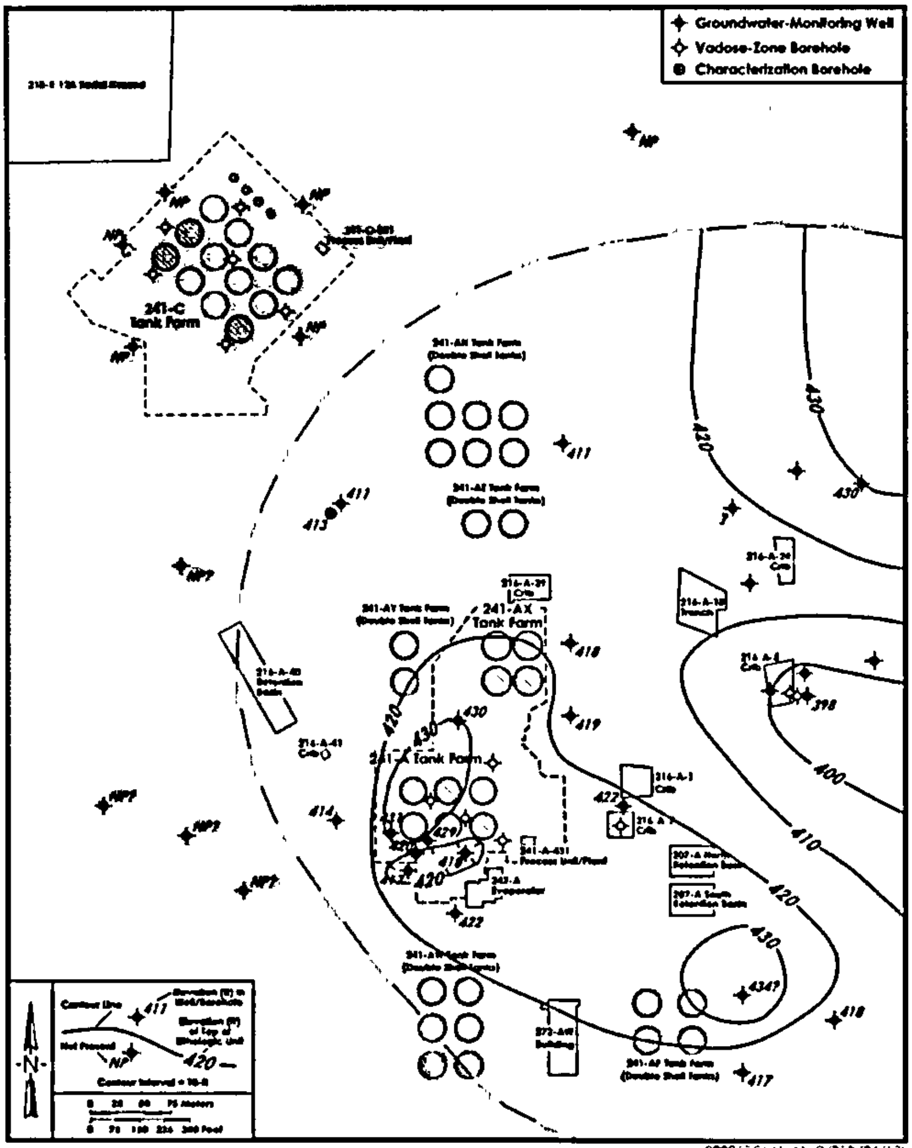
Figure C-9. Structure Contour Map of the Top of the Undifferentiated Plio-Pleistocene Silt/Ringold Formation Mud? [Pplz/R(?)] Unit.

TOP OF PPlz MAP



2002/DCL/A-AX-C/010 (06/12)

Figure C–10. Isopach Map of the Hanford Formation H3 Unit.

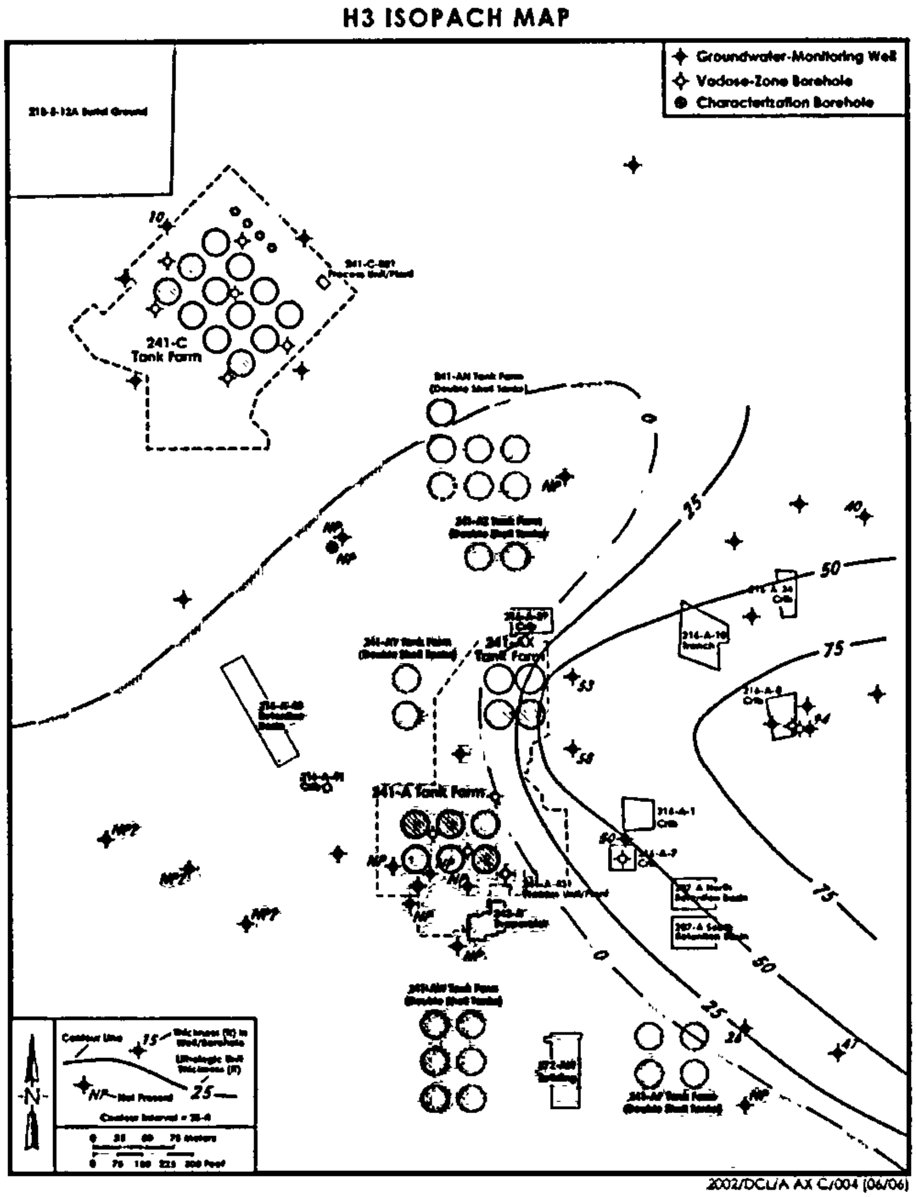


Figure C–11. Structure Contour Map of the Top of the Hanford Formation H3 Unit.

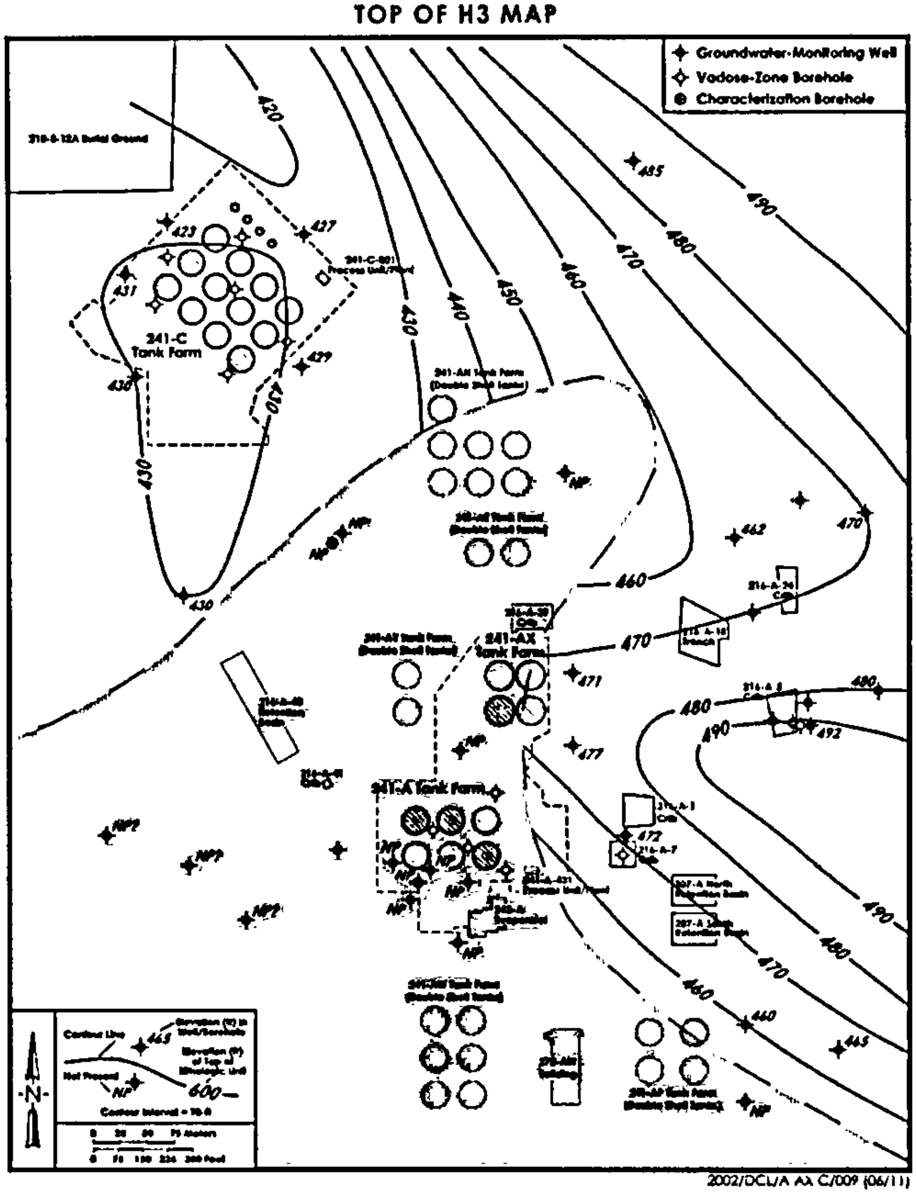


Figure C–12. Isopach Map of the Hanford Formation H2 Unit.

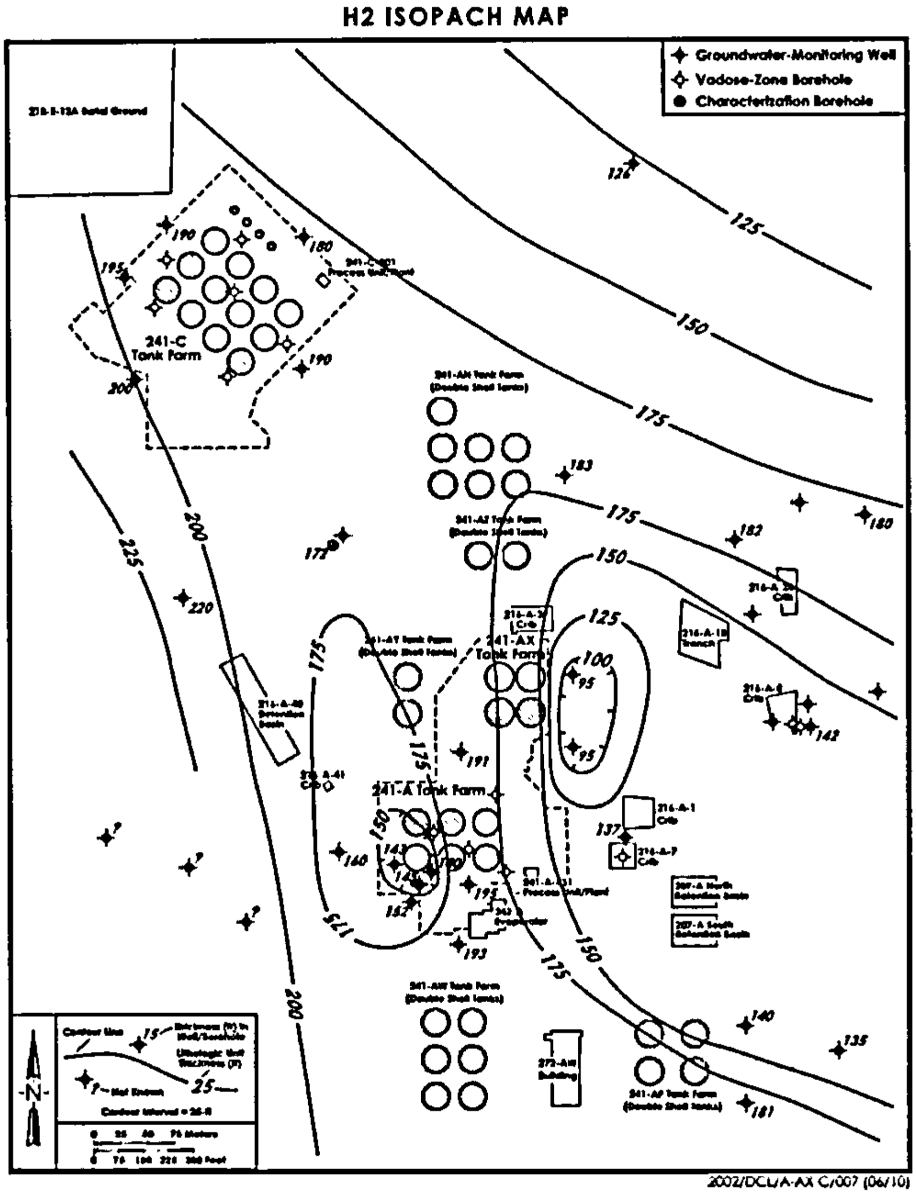


Figure C–13. Structure Contour Map of the Top of the Hanford Formation H2 Unit.

TOP OF H2 MAP

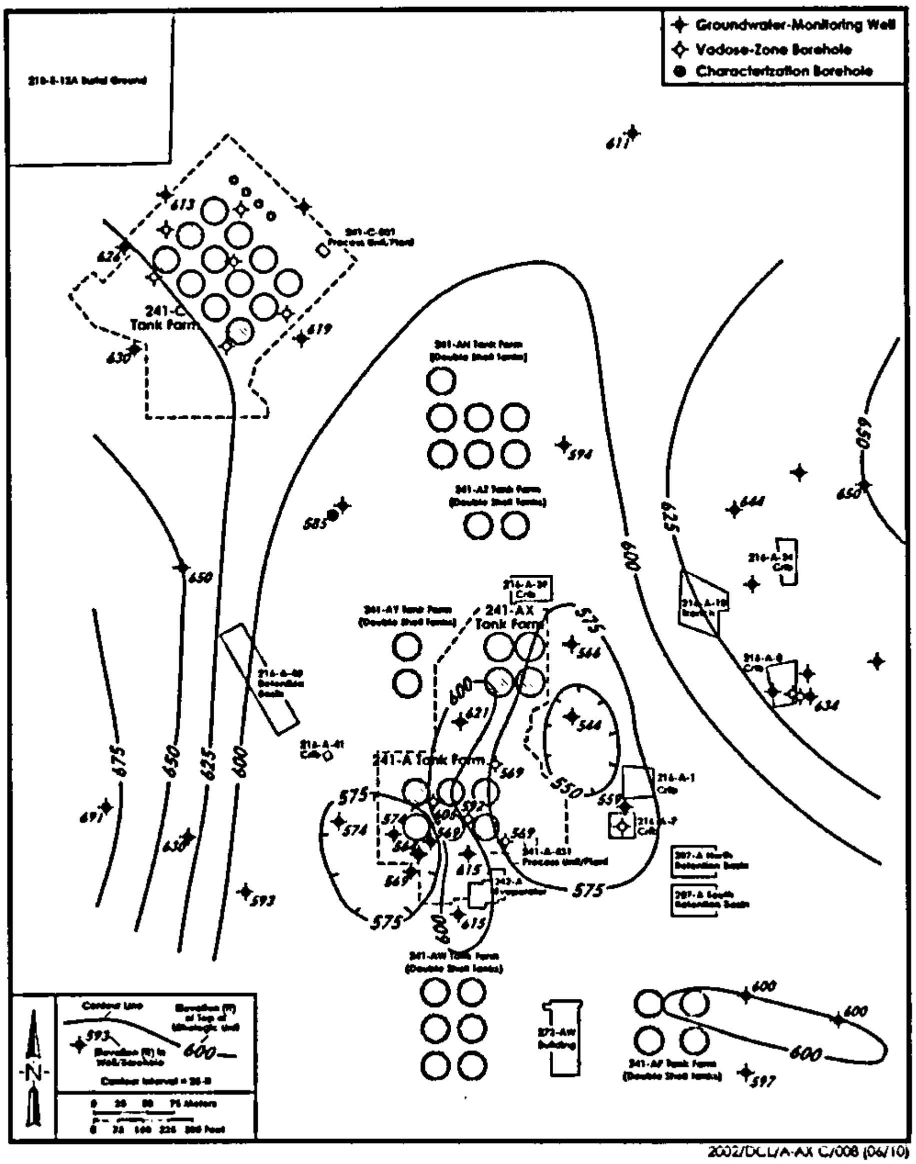


Figure C–14. Isopach Map of the Hanford Formation H1 Unit.

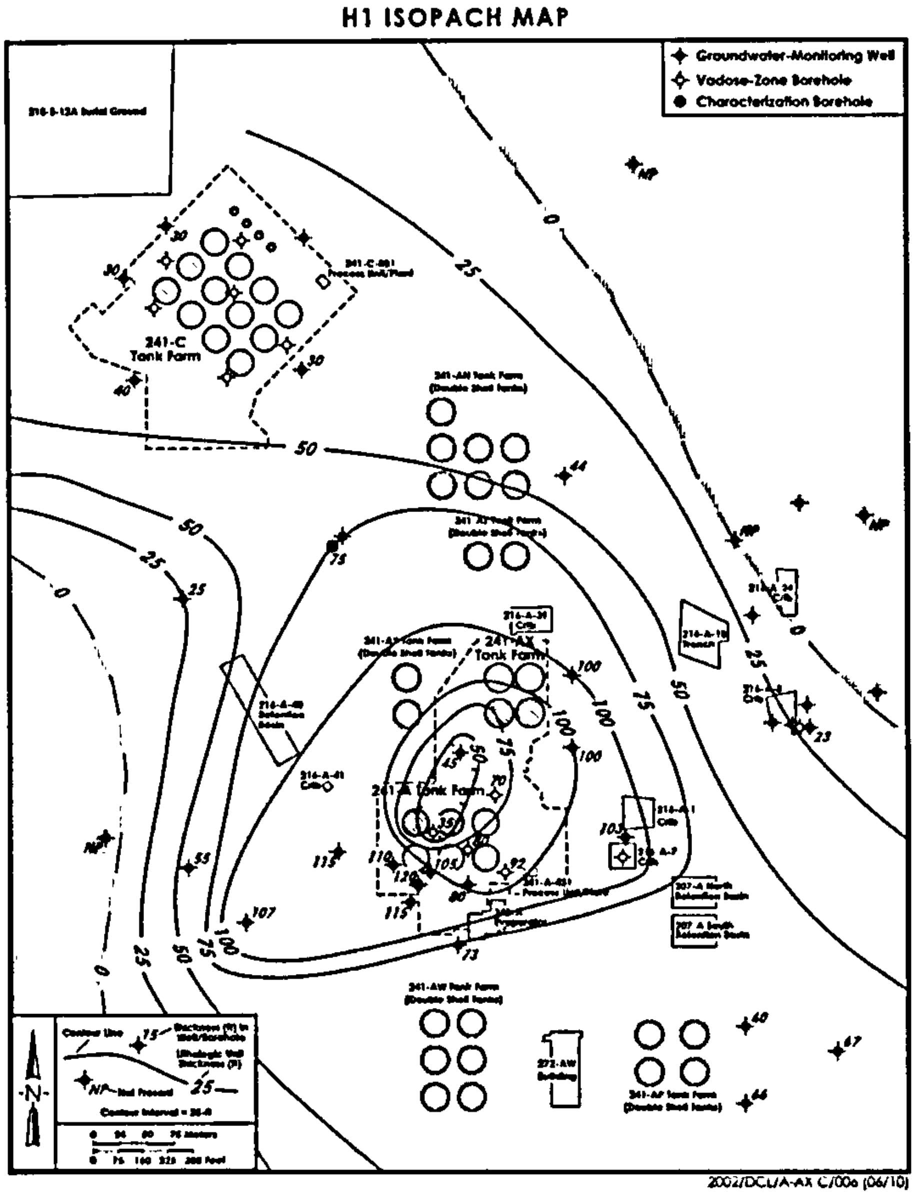
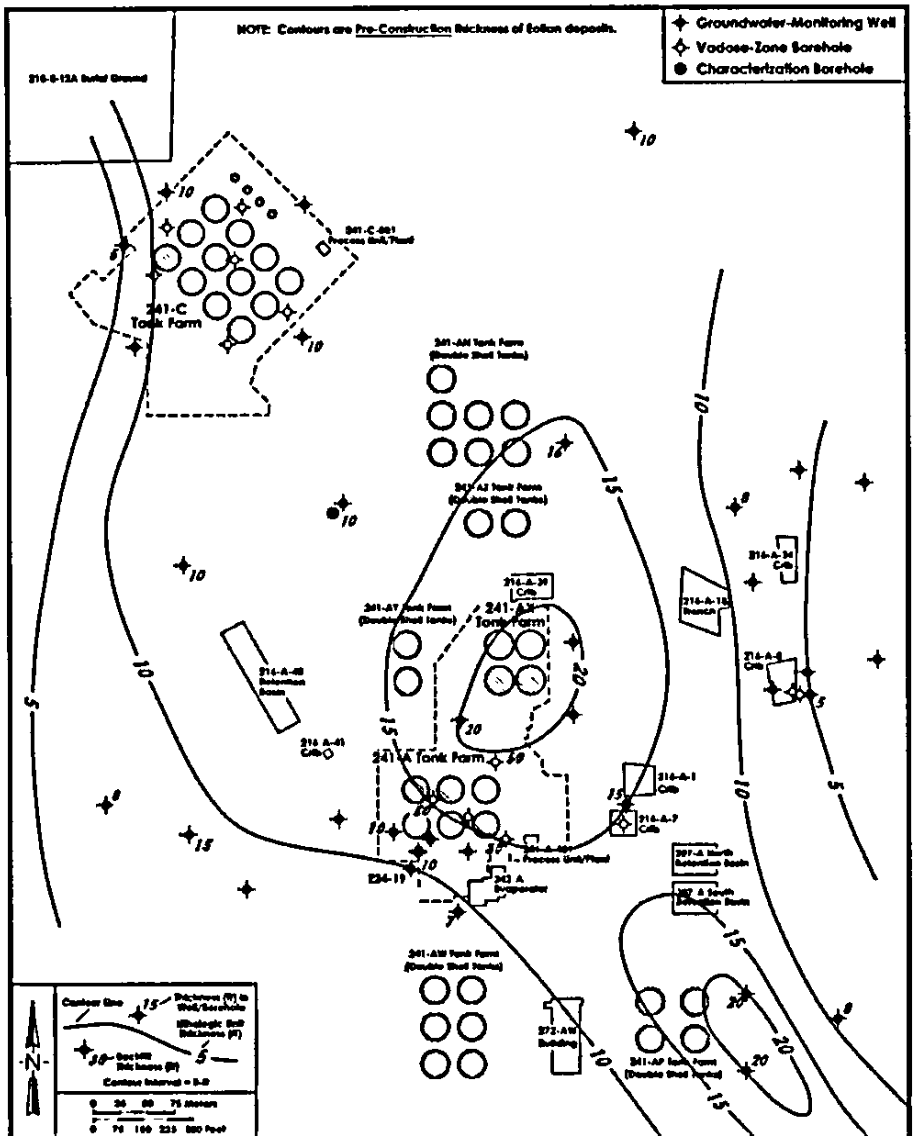


Figure C–15. Isopach Map of the Recent Deposits.

RECENT DEPOSITS (EOLIAN) ISOPACH MAP



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APPENDIX D

SUPPORTING METEOROLOGICAL, HYDROLOGIC DATA

CONTENTS

TABLES

D.1.0 INTRODUCTION

Table D-1 summarizes monthly and annual precipitation at the Hanford Site from 1946 to 1998. Tables D-2 through D-8 summarize the hydrologic soil property data and derived input parameter values used to model contaminant migration through the vadose zone underlying the C WMA (Khaleel et al 2002). These data are derived from soil hydrologic property measurements on Hanford soils collected from numerous sites across the Hanford Site (Khaleel and Freeman 1995). Similar property tables will be developed for the A and AX tank farms.

Table D–1. Monthly and Annual Precipitation at the Hanford Site, 1946 to 1998.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1946	—	—	—	—	—	—	0.15	0.35	0.52	0.65	0.66	0.11	—
1947	0.32	0.27	0.42	0.70	0.02	1.07	0.71	0.68	1.34	2.20	0.81	0.75	9.29
1948	1.36	0.69	0.07	0.95	1.71	1.47	0.40	0.39	0.16	0.45	0.95	1.11	9.71
1949	0.13	0.68	1.12	0.02	0.16	0.01	0.01	0.03	0.23	0.10	1.47	0.16	4.12
1950	1.80	1.06	0.87	0.47	0.27	2.92	0.07	T	0.01	2.46	0.55	0.97	11.45
1951	0.84	0.51	0.46	0.53	0.43	1.38	0.37	0.15	0.10	0.71	0.82	0.70	7.00
1952	0.65	0.50	0.06	0.13	0.58	1.07	T	0.08	0.08	0.04	0.20	0.77	4.16
1953	2.16	0.25	0.17	0.77	0.28	0.55	T	0.96	0.13	0.20	0.96	0.49	6.92
1954	1.48	0.28	0.59	0.07	0.41	0.10	0.22	0.42	0.51	0.42	0.86	0.35	5.71
1955	0.56	0.22	0.17	0.40	0.59	0.28	0.57	0	0.77	0.40	1.54	2.03	7.53
1956	1.71	0.56	0.10	T	0.22	0.86	T	0.38	0.01	1.03	0.15	0.58	5.60
1957	0.48	0.23	1.86	0.38	0.82	0.47	0.05	0.02	0.34	2.72	0.39	0.53	8.29
1958	1.74	1.48	0.46	0.64	0.74	0.81	0.02	T	0.05	0.19	0.77	1.84	8.74
1959	2.05	1.17	0.40	0.20	0.50	0.23	T	0.03	1.26	0.56	0.41	0.26	7.07
1960	0.51	0.58	0.67	0.53	0.71	0.14	T	0.26	0.23	0.23	0.92	0.64	5.42
1961	0.33	2.10	1.02	0.48	0.80	0.42	0.15	0.09	T	0.07	0.49	0.89	6.84
1962	0.13	0.90	0.14	0.34	1.35	0.12	T	0.50	0.38	0.95	0.65	0.60	6.06
1963	0.95	0.69	0.53	1.17	0.43	0.28	0.31	0.01	0.02	0.04	0.74	1.14	6.31
1964	0.37	0.01	0.03	0.11	0.04	0.90	0.04	0.24	0.09	0.28	0.94	2.34	5.39
1965	0.93	0.14	0.03	0.09	0.15	0.49	0.11	0.03	0.11	0.01	1.17	0.39	3.65
1966	0.68	0.03	0.39	0.03	0.05	0.43	0.81	T	0.27	0.39	2.25	0.60	5.93
1967	0.32	T	0.14	0.90	0.56	0.57	T	T	0.05	0.13	0.16	0.43	3.26
1968	0.88	0.58	0.02	0.01	0.06	0.19	0.04	0.51	0.25	0.93	1.23	1.25	5.95
1969	1.24	0.54	0.10	1.22	0.51	0.75	T	T	0.48	0.10	0.13	1.29	6.36
1970	2.47	0.75	0.27	0.45	0.54	0.25	0.01	T	0.03	0.24	0.71	0.61	6.33
1971	0.78	0.10	1.02	0.07	0.56	0.71	0.13	0.09	1.13	0.18	0.46	1.07	6.30
1972	0.19	0.27	0.58	0.10	2.03	0.66	0.16	0.56	0.02	T	0.55	1.27	6.39
1973	0.90	0.21	0.08	T	0.24	0.01	T	0.02	0.43	1.72	2.64	2.02	8.27
1974	0.90	0.41	0.52	0.46	0.28	0.12	0.71	T	0.01	0.21	0.71	0.97	5.30
1975	1.43	0.98	0.33	0.42	0.38	0.24	0.32	1.16	0.03	0.87	0.60	0.70	7.46
1976	0.56	0.33	0.23	0.41	0.08	0.11	0.13	0.96	T	0.04	T	0.11	2.99
1977	0.08	0.57	0.41	T	0.65	0.37	0.06	1.36	0.66	0.15	0.63	1.47	6.41
1978	1.72	0.92	0.30	0.46	0.41	0.09	0.52	0.57	0.11	T	1.21	0.26	6.57
1979	0.54	0.17	0.54	0.52	0.10	T	0.09	0.38	0.20	0.67	1.36	0.99	5.56
1980	1.32	1.30	0.30	0.86	1.41	0.96	T	0.02	0.85	0.33	0.44	1.89	9.68
1981	0.56	0.60	0.70	0.02	0.99	0.43	0.19	0.03	0.60	0.39	1.08	1.45	7.04
1982	0.33	0.57	0.30	0.75	0.28	0.75	0.22	0.20	0.55	1.33	0.91	1.79	7.98

Table D–1. Monthly and Annual Precipitation at the Hanford Site, 1946 to 1998.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1983	1.44	1.36	1.00	0.42	0.52	0.68	0.31	0.12	0.46	0.52	2.12	2.12	11.07
1984	0.23	0.94	1.01	0.60	0.55	0.99	0.06	T	0.42	0.07	1.83	0.57	7.27
1985	0.34	0.82	0.36	0.01	0.12	0.15	0.12	0.01	0.63	0.46	1.24	0.84	5.10
1986	1.76	1.37	0.76	T	0.30	T	0.21	0.02	0.96	0.29	0.65	0.77	7.09
1987	0.80	0.19	1.05	0.14	0.17	0.11	0.50	0.07	0.01	T	0.40	1.63	5.07
1988	0.48	T	0.39	1.12	0.33	0.11	0.13	0	0.39	0.01	0.82	0.40	4.18
1989	0.21	1.67	1.56	0.84	0.59	0.01	0.01	0.26	0.02	0.42	1.04	0.29	6.92
1990	0.77	0.09	0.10	0.40	0.86	0.36	0.14	0.83	T	0.78	0.02	0.72	5.07
1991	0.33	0.19	1.12	0.45	0.49	1.44	0.29	0.07	0	0.53	1.44	0.40	6.75
1992	0.44	0.94	0.09	0.94	T	1.14	0.39	0.20	0.27	0.61	1.07	1.82	7.90
1993	1.30	1.17	0.67	0.71	0.60	0.12	1.76	0.24	0.04	0.09	0.19	0.94	7.83
1994	0.44	0.11	0.03	0.61	1.27	0.38	0.15	0.08	0.08	0.93	0.68	1.36	6.12
1995	2.14	0.69	0.95	1.54	0.79	0.77	0.34	0.07	0.79	0.87	1.04	2.32	12.31
1996	1.42	1.22	0.83	0.43	0.62	0.05	0.14	0.02	0.22	0.88	2.67	3.69	12.19
1997	1.51	0.25	0.70	0.33	0.33	0.46	0.19	0.06	0.32	0.92	1.01	0.31	6.39
1998	1.24	1.15	0.50	0.07	0.52	0.48	0.34	0.04	0.10	0.28	1.29	0.44	6.45
Average													
	0.93	0.63	0.51	0.45	0.53	0.53	0.22	0.24	0.32	0.55	0.91	1.01	6.82
Norm													
	0.79	0.62	0.47	0.41	0.51	0.38	0.18	0.27	0.31	0.39	0.91	1.03	6.26

Table D–2. Van Genuchten Parameters, Fitted Saturated Hydraulic Conductivity, and Measured Bulk Density Data for the Backfill (1) and Plio-Pleistocene/Ringold Sandy Gravel (5) Sediments (Khaleel Et Al 2002).

Sample	Site/ Operable Unit	Borehole Number	Depth (m)	Percent Gravel	θ_s (cm^3/cm^3)	θ_r (cm^3/cm^3)	α (1/cm)	n (-)	Fitted K_s (cm/s)	Bulk Density (g/cm^3)
4-0792	ERDF	699-35-65A	75.4	71	0.100	0.0084	0.03	1.5858	3.42E-04	2.32
4-1012	ERDF	699-35-69A	73.9	55	0.147	0	0.0076	1.5109	4.50E-05	2.19
4-1013	ERDF	699-35-69A	77.9	65	0.139	0.0127	0.0065	1.5656	1.06E-06	2.20
4-1079	ERDF	699-35-61A	90.9	61	0.163	0	0.014	1.3079	1.18E-04	2.06
4-1080	ERDF	699-35-61A	93.5	43	0.178	0	0.0074	1.3819	8.11E-06	2.00
3-0668	241-T-106	299-W10-196	38.9	62	0.175	0	0.0192	1.6124	1.63E-04	2.13
3-0682	241-T-106	299-W10-196	46.1	51	0.224	0	0.0166	1.6577	2.37E-04	2.14
3-0688	241-T-106	299-W10-196	48.5	49	0.199	0	0.0043	1.5321	2.60E-05	2.17
3-0689	241-T-106	299-W10-196	52.2	28	0.236	0	0.0025	1.4747	4.58E-05	1.93
3-0690	241-T-106	299-W10-196	53.7	53	0.1819	0.0177	0.0046	1.541	4.19E-05	2.19

Table D–3. Van Genuchten Parameters, Fitted Saturated Hydraulic Conductivity,and Measured Bulk Density Data for the Sandy H2 (2) Sequence (Khaleel Et Al 2002).

Sample	Site/ Operable Unit	Borehole Number	Depth (m)	Percent Gravel	θ_s (cm^3/cm^3)	θ_r (cm^3/cm^3)	α (1/cm)	n (-)	Fitted K_s (cm/s)	Bulk Density (g/cm^3)
3-0589	241-T-106	299-W10-196	25.5	1	0.429	0.0268	0.0057	1.7173	4.73E-05	1.86
3-1707	200-UP-2	299-W19-95	9.5	15	0.364	0.0742	0.0082	2.0349	1.55E-05	1.86
3-1712	200-UP-2	299-W19-95	43.1	0	0.290	0.0362	0.0156	2.021	2.05E-04	1.71
3-1713	200-UP-2	299-W19-95	46.3	0	0.5026	0	0.0077	1.6087	2.51E-05	1.72
3-1714	200-UP-2	299-W19-95	50.8	2	0.394	0.1301	0.0061	1.535	1.05E-04	1.68
4-0637	ERDF	699-36-63A	74.9	0	0.378	0	0.0153	1.7309	6.89E-05	1.62
4-0642	ERDF	699-35-69A	25.7	0	0.353	0.0286	0.014	1.4821	6.81E-04	1.98
4-0644	ERDF	699-35-69A	49.8	0	0.394	0.0557	0.0076	1.8353	3.24E-05	1.89
4-0791	ERDF	699-35-65A	63.2	0	0.338	0.0256	0.0226	2.2565	6.81E-04	1.60
4-1076	ERDF	699-35-61A	76.4	0	0.357	0	0.0293	1.7015	1.23E-03	1.74
4-1111	200-UP-1	699-38-68A	56.9	1	0.394	0.0497	0.0093	1.4342	5.80E-05	1.69
4-1112	200-UP-1	699-38-68A	66.0	0	0.4346	0	0.0054	1.4985	2.49E-05	1.73

Table D–4. Van Genuchten Parameters, Fitted Saturated Hydraulic Conductivity, and Measured Bulk Density Data for the Gravelly Sand H3 (3) Sequence (Khaleel Et Al 2002).

Sample	Site/ Operable Unit	Well Number	Depth (m)	Percent Gravel	θ_s (cm^3/cm^3)	θ_r (cm^3/cm^3)	α (1/cm)	n (-)	Fitted K_s (cm/s)	Bulk Density (g/cm^3)
3-0210	241-T-106	299-W10-196	3.1	48	0.186	0.029	0.014	1.7674	1.96E-04	2.11
3-0572-2	100-FR-3	199-F5-48	8.1	27	0.179	0	0.0031	1.4306	2.38E-05	2.03
3-0576	100-FR-3	199-F5-43B	5.4	20	0.244	0.0166	0.0167	1.5428	3.96E-04	1.95
3-0668	241-T-106	299-W10-196	38.9	62	0.175	0	0.0192	1.6124	1.63E-04	2.13
3-0682	241-T-106	299-W10-196	46.1	51	0.224	0	0.0166	1.6577	2.37E-04	2.14
3-0688	241-T-106	299-W10-196	48.5	49	0.199	0	0.0043	1.5321	2.60E-05	2.17
3-0689	241-T-106	299-W10-196	52.2	28	0.236	0	0.0025	1.4747	4.58E-05	1.93
3-0690	241-T-106	299-W10-196	53.7	53	0.1819	0.0177	0.0046	1.541	4.19E-05	2.19
5-0152	218-E-12B	299-E34-1	65.5	26	0.280	0.0252	0.0438	1.3253	2.43E-03	1.85
5-0153	218-E-10	299-E32-4	10.7	47	0.214	0.0092	0.0099	1.3829	1.41E-04	2.08
5-0158	218-E-10	299-E32-4	71.6	44	0.217	0	0.0104	1.3369	4.47E-04	2.15

Table D–5. Van Genuchten Parameters, Fitted Saturated Hydraulic Conductivity, and Measured Bulk Density Data for the Gravelly Sand H1 (4) Sediments (Khaleel Et Al 2002).

Sample	Site/ Operable Unit	Borehole Number	Depth (m)	Percent Gravel	θ_s (cm^3/cm^3)	θ_r (cm^3/cm^3)	α (1/cm)	n (-)	Fitted K_s (cm/s)	Bulk Density (g/cm^3)
3-0572-2	100-FR-3	199-F5-48	8.1	27	0.179	0	0.0031	1.4306	2.38E-05	2.03
3-0576	100-FR-3	199-F5-43B	5.4	20	0.244	0.0166	0.0167	1.5428	3.96E-04	1.95
3-1707	200-UP-2	299-W19-95	9.5	15	0.364	0.0742	0.0082	2.0349	1.55E-05	1.86
5-0149	218-E-12B	299-E34-1	24.4	16	0.260	0	0.0082	1.4422	1.80E-04	2.07
5-0150	218-E-12B	299-E34-1	24.84	17	0.240	0.0227	0.0295	1.7077	1.47E-03	1.95
5-0151	218-E-12B	299-E34-1	21.49	17	0.275	0	0.0049	1.4621	6.85E-05	1.95
5-0152	218-E-12B	299-E34-1	65.5	26	0.280	0.0252	0.0438	1.3253	2.43E-03	1.85
5-0157	218-E-10	299-E32-4	3.50	13	0.293	0.033	0.0273	2.1675	7.77E-03	1.88

Table D–6. Composite van Genuchten-Mualem parameters for vadose zone strata (Khaleel et al 2002).

Strata	Number of samples	θs	θr	α (1/cm)	n	ℓ	Fitted K_s (cm/s)
Backfill (1)	10	0.1380	0.0100	0.0210	1.374	0.5	5.60E-04
Sand H2 (2)	12	0.3819	0.0443	0.0117	1.6162	0.5	9.88E-05
Gravelly Sand H3 (3)	11	0.2126	0.0032	0.0141	1.3730	0.5	2.62E-04
Gravelly Sand H1 (4)	8	0.2688	0.0151	0.0197	1.4194	0.5	5.15E-04
Plio-Pleistocene/ Ringold Sandy Gravel (5)	10	0.1380	0.0100	0.0210	1.374	0.5	5.60E-04

Table D–7. Macroscopic Anisotropy Parameters, Based on Polmann (1990) Equations for Various Strata (Khaleel Et Al 2002).

Strata	Number of samples	$<LnK_s>$	$\sigma^2_{LnK_s}$	p	ζ	λ (cm)	A
Backfill (1)	10	-15.76	3.56	-1.1E-4	1.84E-4	30	0.00371
Sandy H2 (2)	12	-14.59	1.50	-7.2E-4	6.55E-4	50	0.00620
Gravelly Sand H3 (3)	11	-14.85	1.94	-2.6E-4	2.50E-4	30	0.00368
Gravelly Sand H1 (4)	8	-15.3	1.83	-5.6E-4	5.16E-4	50	0.00415
Plio-Pleistocene/ Ringold Sandy Gravel (5)	10	-15.76	3.56	-1.1E-4	1.84E-4	30	0.00371

Table D–8. Non-reactive macrodispersivity estimates for non reactive species in vadose zone strata (Khaleel et al 2002).

Strata	σ^2_{LnK}	Correlation length, λ (cm)	A_L (cm)	A_T (cm)
Backfill (1) and Plio-Pleistocene/ Ringold Sandy Gravel (5)	4.54	30	~150	15
Sandy H2 (2)	4.60	30	~150	15
Gravelly sand H3 (3)	3.19	30	~100	10
Gravelly sand H1 (4)	4.95	30	~100	10

D.2.0 REFERENCE

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APPENDIX E

SUPPORTING GAMMA LOGGING DATA